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SHORT SHEET: TRW RECOMMENDATIONS FOR SAMPLING AND ANALYSIS OF SOIL AT LEAD (Pb) SITES

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U.S. Environmental Protection Agency
Technical Review Workgroup for Lead

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TRW Recommendations for Sampling and Analysis of Soil at Lead (Pb) Sites

Background

Incidental ingestion is the major pathway of exposure to lead in soil and dust.[1] The assumption implicit in this exposure pathway is that ingested soil and dust lead is best represented by the lead concentration in the particle size fraction that sticks to hands (and perhaps clothing and other objects that may be mouthed). EPA lead models consider this fraction to be the primary source of the ingested soil and dust. Several studies indicate that the particle size fraction of soil and dust that sticks to hands is the fine fraction and that a reasonable upper-bound for this size fraction is 250 microns (μm) (Kissel *et al*, 1996; Sheppard and Evenden, 1994; Driver *et al.*, 1989; Duggan and Inskip, 1985; Que Hee, *et al.*, 1985; Duggan, 1983). This is also the particle size fraction that is most likely to accumulate in the indoor environment, as a result of deposition of wind-blown soil and transport of soil on clothes, shoes, pets, toys, and other objects.

A TRW review of data from CERCLA sites has demonstrated that the lead concentration in the fine fraction often differs from the lead concentration in the total soil sample. The fraction less than 250 μm is most often measured, but data are available on smaller size fractions as well. This difference in lead concentration between the fine fraction and the total soil sample has also been reported by a number of investigators (Fergusson and Ryan, 1984; Fergusson and Schroeder, 1985; Kitsa *et al.*, 1992), and enrichment of lead and other metal contaminants in the fine fraction is suggested. In the development of his *de minimis* model for lead exposure to children, Stern (1994) recommended a generic correction for enrichment of lead in the exposure fraction.

Lead concentration data for the fine (<250 μm) fraction (Midvale data) were used in the calibration of the EPA Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children, and in the characterization of lead bioavailability in soil, using either *in vivo* or *in vitro* studies (Casteel *et al.*, 1997; Maddaloni *et al.*, 1998; Ruby *et al.*, 1996).

While estimates of the lead concentrations in the fine particle fraction from sieved soil samples are considered to be most relevant for assessment of current lead risks at sites, there is also value in obtaining data on the concentration of lead in unsieved (total) soil samples (or alternately, joint data on concentrations in both the total and fine soil fractions). Data to compare concentrations of lead in fine and total fractions are particularly important if either routine or confirmatory site sampling during cleanup activities will use total soil sample concentrations. In this case, data on the relative lead concentrations in the two fractions may be used to develop a site-specific "adjusted" cleanup level that would be applicable to total soil sampling data.

Second, while it is generally expected that fine soil fractions will be "enriched" in lead compared to total soil fractions, in certain cases, the opposite situation may occur. In some soils, the total soil fraction may contain high concentrations of lead (*e.g.*, if coarse materials from mining or industrial operations contained high concentrations of lead). When coarser materials contain high lead concentrations, concerns about the future degradation of these coarser materials into finer particles should be addressed by using the total soil concentration for developing response actions at a site. In addition, total soil concentrations would be more representative of deliberate soil ingestion (pica) than fine fraction concentrations.

The following is a standard set of recommendations and protocols developed for the collection, preparation, and analysis of lead in soil and dust for use in lead modeling exercises. The goal is to assure that a given lead concentration in soil or dust means the same thing in every case, because consistency at sites is of major concern.

TRW Recommendations

Because the concentration from the fine fraction is relevant for exposure from incidental soil ingestion, it is the preferred concentration input in modeling lead risks. Data on the fine fraction (<250 μm) is the recommended input for the IEUBK and Adult Lead models.

- If there is a potential for the coarse fraction to contain a higher concentration of lead than the fine fraction, then at least 20% of the surface soil samples, or a minimum of 20 samples, should be analyzed for lead concentration in both the coarse (>250 μm) and the fine (<250 μm) particle size

[1] It is known that some children exhibit pica for soil (deliberate ingestion of soil) and that these children may have soil ingestion rates well in excess of the typical ingestion levels used in the IEUBK model or most EPA risk assessments.

fractions. This data should allow for statistical analysis to compare concentrations in the total and fine fractions. In addition, if prior soil sampling data are available, such analysis may allow for comparison with earlier sampling data.

- At sites where conditions are sufficiently uniform, the fine fraction lead concentration may be estimated from the total fraction lead concentration. This approach will be most useful if the ratio between the concentrations in the two fractions (the enrichment ratio) is constant across sampling locations. For practical purposes, an enrichment ratio that varies by 10%–20% may be sufficiently constant for most applications. Statistical regression models can also be useful in examining the relationship between concentrations in the different soil fractions. For example, data may support a regression model predicting the fine fraction concentration from the total fraction concentration (potentially with other covariates). It is recommended that assistance from a statistician be obtained in developing and evaluating such regression models. A few key points to consider: An estimated slope relating the fine fraction concentration to the total concentration should not be used to estimate fine fraction concentrations, instead predictions should be based on the full regression analysis. The p-value and r^2 statistics output from most regression programs provide useful indicators for the presence of a relationship between model variables, but are not sufficient to evaluate the level of error in modeling. Regression models should be presented so as to provide best estimates of the fine fraction concentrations (the regression line) and to predict errors about the regression line. Unless prediction errors are relatively small (10–20% of the best estimates), it is recommended that upper bound values for predicted fine fraction concentrations be used for site applications. Where substantial error exists in the prediction of fine fraction concentrations, this should generally signal the importance of measuring, rather than estimating, fine fraction concentrations (especially in locations where the exceedance of a cleanup goal may be in question).

- A 250 μm (No. 60) sieve (ASTM, 1999) is the recommended maximum sieve size that should be used for sieving soil samples. Other sieve sizes may be used under certain circumstances, but both the cost of sample preparation and the lead enrichment in the fine fraction are expected to increase with decreasing sieve size.

- If only one analysis is to be performed on soil at a lead contaminated site, as is often done at a removal site, the preference is for analysis of the fine fraction only, because it provides the best characterization of the current risk from exposure by incidental ingestion.

- A reasonable preparation procedure consists of drying the sample and then carefully sieving it though a No. 4 (4.75 mm) or a No. 10 (2.0 mm) sieve (ASTM, 1999) to remove the "sticks and stones" (large debris). The resulting material is the bulk or total soil sample. The suggested methodology would be to sieve the entire weighed total sample; then weigh and analyze both the coarse (> 250 μm) and fine (< 250 μm) fractions and reconstruct the total soil concentration using weighted averaging, or to simply weigh and analyze only the fine fraction.

At this time, the TRW does not have any specific recommendations for sample preparation and analysis of soil samples for other metals or contaminants. Recommendations for contaminants other than lead may differ due to the differences in the methodologies employed for the assessment of risk for these contaminants, although samples analyzed for lead are often analyzed for the full suite of metals through the EPA's Contract Laboratory Program.

Definitions

Total soil sample: the soil that remains after passing a soil sample through a No. 4 (4.72 mm) or a No. 10 (2.0 mm) sieve to remove large debris, such as sticks and stones. The total soil sample consists of the coarse and fine fractions.

Coarse fraction: the portion of the total sample that does not pass through a 250 μm sieve.

Fine fraction: the portion of the total sample that passes through a 250 μm sieve. This is the fraction most likely to stick to hands and be ingested.

Enrichment ratio: the concentration of lead in the fine fraction relative to the concentration of lead in the total fraction. This ratio will vary across and even within sites.

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